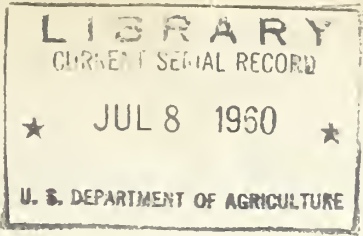


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³ ALTITUDE TESTS WITH FLOWERS;
(Effect of simulated air cargo flights)//

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ALTITUDE TESTS WITH FLOWERS
(Effect of simulated air cargo flights)

Changes in altitude, temperature, and humidity encountered in transcontinental flights of cargo planes may affect the life of cut flowers shipped by air. Previous tests have shown that altitudes usually attained by cargo planes have no harmful effect upon fruits and vegetables but high temperature and low humidity that may be encountered en route are detrimental (H. T. & S. Office Report 197). The purpose of this investigation was to determine the effect of altitude on cut flowers and to obtain information concerning the refrigeration and moisture requirements for successful shipment by air. The general plan was to subject commercially packed cut flowers to various environmental conditions of temperature and humidity in a large decompression chamber in which flights up to 50,000 ft. altitude were simulated and to compare the subsequent condition of the flowers with similar lots held at sea level.

Cut flowers representing 17 varieties available in the spring and 5 varieties available during the fall were used, Table 1. No injury was discernible following exposure to altitudes of 10,000 ft. to 20,000 ft. Most of the flowers were uninjured at 30,000 to 50,000 ft. but at these extremely high altitudes carnations, chrysanthemums, sweet peas and roses suffered slight to severe curling of the petals due to excessive drying at the edges, Figs. 1, 2, and 3. They also suffered more than the other flowers from lack of refrigeration and moisture while packed for shipment. The results of a few trials indicate that moistureproof box liners or moistureproof shipping boxes can be used to reduce the loss of water from flowers and thus lengthen flower life.

Although anemone, delphinium, ranunculus, and snapdragon were not injured by altitude, they were usually too short lived to be of value for distant shipment under the conditions of these tests.

Test Procedure

The flowers were obtained at the Los Angeles wholesale market early on the day of the test by representatives of the Southern California Floral Association. The flowers had been cut the previous evening and then hardened in water until about midnight before hauling to market. In most instances packing of the boxes at the market was done in the usual manner for shipment of mixed flowers using newspaper liners (5 layers), tissue wrappers, newspaper cushions to separate the bunches, and wooden cleats for bracing, Fig. 4. Large size 36-inch corrugated fiberboard boxes, 20" wide and 11" deep, containing about 25 pounds of flowers were used in the first four tests. Thereafter a smaller box of the same length, 15" wide and 9" deep, holding about 10 pounds of flowers was used for convenience in handling. Five pounds of ice was used for package refrigeration. In most tests it was placed in a moistureproof bag, wrapped with newspaper and tied to the center cleat of the box. In some tests the bags were eliminated and in others different methods of icing were tried including dry ice and "Superice" which is sawdust soaked with a light brine then frozen solid. The effect of moistureproof box liners and boxes was also studied.

The tests were made at the Lockheed Aircraft Corporation laboratory in a large decompression chamber which was equipped for control of temperature, humidity, and air pressure to simulate flight conditions in airplanes, Fig. 5. Temperature of flowers and air inside the chamber was obtained with distant reading electric thermometers (thermocouples) connected to a suitable indicator

(potentiometer) outside. Humidity measurements were made by observing a hair type recording hygrometer placed in the chamber.

A typical test schedule as used with tests 1 and 2 called for simulated ascent at 2,000 ft. per minute to 20,000 ft. altitude, holding at this level for 2 hours and then descending to sea level at a rate of 2,000 ft. per minute. This cycle was repeated 4 times to represent 3 ground stops in a cross country flight of 10 to 12 hours at 20,000 ft. altitude. Immediately after the "flight" the flowers were transferred to a small walk-in type ice box which was used also for holding similar lots (controls) at sea level for comparison. The following morning, or about 24 hours after packing, the stems were cut and the flowers were placed in water to refresh. Later they were transferred to a warm room for display and further observation.

In most tests some flowers were unpacked and held "exposed" in the altitude chamber for observation through the windows of the altitude chamber during the "flight," Fig. 6.

Results

The conditions of the simulated flights are shown in Table 2. Since the tests included different aspects of packing and cooling of flowers along with the study of the effect of altitude they will be discussed in the order in which they were made.

Tests Nos. 1 and 2 represent warm-dry and cool-humidified transcontinental flights at 20,000 ft. altitude. Fifteen kinds of flowers available in April were used, Fig. 7. They were packed in large size 36-inch boxes each containing 5 pounds of ice in a moistureproof bag which was tied to the center cleat of Box No. 1 and to an end cleat of Box No. 4 used in Test No. 1. The ice was also attached to an end cleat of the single box used in test No. 2.

The flowers which had an initial temperature of 65°F. cooled only 6 degrees in ten hours when the air temperature was 60° to 65° (test No. 1) compared with 18 degrees cooling in 40° to 45° air temperature (test No. 2) Fig. 8. Also, the stems near the ice cooled slightly faster in test No. 2 than in test No. 1. Commodity temperatures at the uniced (dry) ends of the boxes in test No. 1 were similar regardless of the position of the ice, Fig. 8. Likewise, the cooling of the stems near the ice was similar in both boxes. However, the center of box No. 4 iced at one end was much warmer than the center of box No. 1 iced at the center and was only slightly cooler than the uniced end of the box, Fig. 8.

In these tests there was no altitude injury and the flowers subjected to reduced atmospheric pressure were in as good conditions as comparable lots (controls) held at sea level, Tables 3 and 4. The lower air temperature (40 to 45°F.) prevailing in test No. 2 was much more favorable for carnations than the warmer air in test No. 1, but apparently it was still too warm and dry for roses since they developed a bluish cast and aged rapidly. The packed lots of calla, cornflower, daisy, godetia, iris, and stock refreshed normally following both tests. Anemones, delphiniums, ranunculus, and sweet peas were too short lived to hold up either at sea-level or in flight during the test.

Unpacked (exposed) flowers wilted much more than packed lots during the "flights" but there was no excessive dropping of petals (shatter) or abnormal

opening of blossoms (blasting) at high altitude. Owing to the lower temperature and higher humidity in test No. 2 mixed bunches of stock and delphinium exposed to the air lost only 6.4 percent moisture during the flight period in test No. 2 as compared with a loss of 9.5 percent in test No. 1.

Tests Nos. 3 and 4 simulated relatively short flights at extremely high altitudes comprising two 2-hour periods at 30,000 ft. (test No. 3) and one 2-hour period at 50,000 ft. (test No. 4). Carnations, delphiniums, gardenias, sweet peas, sweetwilliams, stocks, and snapdragons were used. The method of packing and icing the flowers was the same as used in test No. 2.

With the ambient air of both tests averaging about 45°F. and 80 percent humidity the flowers cooled about 7 degrees in 2 hours from an initial temperature of 50° to 55°, which is about the same as occurred under similar conditions in test No. 2.

Following the "flights" at these high altitudes most of the flowers refreshed normally when placed in water. However, roses developed slight withering at the edge of the petals after exposure to 30,000 ft. altitude and excessive withering after exposure to 50,000 ft. altitude. Carnations and sweet peas were similarly affected at 50,000 ft. altitude but to a lesser degree than roses, Table 5.

The sealed transparent bags in which some of the sweet peas were placed ballooned during the rapid ascent and in some instances split open at the seams.

Tests 5, 6, and 7 simulated transcontinental flights at 10,000 ft. to 15,000 ft. altitudes. This represents normal altitudes for non-pressurized cargo planes and also conditions maintained in pressurized compartments of planes at higher altitudes. The altitude chamber was precooled to 45°F. before starting the test and thereafter the refrigeration was used only during stops at sea level as might be done at airports with auxiliary portable coolers. Under these conditions the mean temperature of the ambient air rose gradually from 45° to 65° during the 12-hour "flight" period and the humidity dropped from 77 percent to 48 percent, Fig. 9.

The flowers were packed in small size 36" boxes with the ice package tied to the center cleat. Several methods of icing and packing were used as follows to compare their effect on the temperature and condition of the flowers:

Test	Box No.	Liner	Icing ^{1/}	Remarks
5	1	Oiled paper	"Superice"	Waxed box, hot waxed inside.
5	2	do.	Ice, no bag	Wet paper over stems.
5	3	do.	Ice, bag	Stems dry.
6	1	Newspaper	Superice	
6	2	do.	Ice, no bag	Wet paper over stems.
6	3	do.	Ice, dry ice	Wet paper over stems.
6	4	do.	Ice, bag, dry ice	Stems dry.
7	1	do.	Superice	
7	2	do.	Ice, no bag	Stems wet.
7	3	do.	Ice, dry ice	Stems wet.
7	4	do.	Ice, bag, dry ice	Stems dry.

^{1/} Weights, water ice 5 lbs.; dry ice 1 lb.; "Superice" 5 lbs.

Typical temperatures as obtained in boxes Nos. 2 and 4 in test No. 6 are shown in Fig. 9. These boxes also represent the extremes in the amount of supplemental moisture applied to the flowers. Cooling of the blossoms near the ends of the boxes was nearly the same in all instances. The presence of ice or other coolant in the box resulted in some temperature reduction and kept the flowers below 55°F. despite the warming of the ambient air. With water ice alone (Box No. 2) the stems cooled about the same as the blossoms, but with water ice and dry ice (Box No. 4) considerably lower stem temperatures were obtained as was to be expected due to the low subliming temperature of dry ice. Temperatures obtained with superice were similar to those of Box No. 4.

The flowers in the "wet" packs, those supplied with supplemental moisture from melting ice and from wet paper laid over the stems, were fresher and had longer life than those in drier packs in which the ice was held in moisture-proof bags and where no wet paper was used, Tables 6, 7, and 8. They also lost less moisture during the flight period as shown by the following comparison of packs:

Pack	Test	Box No.	Wt. loss during 12-hour "flight" period.		
			Carnation Pct.	Rose Pct.	Sweet pea Pct.
Wet	5	2	-	2.3	3.7
	6	2	.6	1.2	.6
	7	2	1.3	1.4	.8
	Mean		.95	1.63	1.70
Dry	5	3	-	5.7	5.9
	6	4	2.5	3.1	2.9
	7	4	1.7	1.6	1.6
	Mean		2.10	3.45	3.45

Test No. 8 simulates a transcontinental flight at 20,000 ft. altitude similar to tests Nos. 1 and 2 but with fall flowers. Carnations, chrysanthemums, roses, and sweet peas were used in three small 36" boxes. The individual boxes were treated as follows:

Box A: Lined with thin aluminum foil to retard moisture loss and with flower bunches wrapped in pliofilm for further protection against water loss. Iced with 5 pounds of water ice in a moisture-proof bag and 1 pound of dry ice outside the bag.

Box B: Same as Box A but with 4 additional bags of water ice to obtain greater cooling, making a total of 25 pounds of water ice and 1 pound of dry ice in the box.

Box C: A conventional pack lined with newspaper and with tissue used for bunch wrappers, iced like Box A.

The temperature of the flowers when packed ranged from 70° to 72°F. before the ice was added. With ambient air of 50° to 60° and 40 percent to 55 percent humidity the flowers in the heavily iced Box B cooled 23 degrees compared with 12 degrees and 18 degrees respectively in conventionally iced Boxes A and C, Fig. 10.

There was no injury to the flowers due to altitude and all lots compared favorably with those held at sea level, although again the roses were affected by a lack of adequate refrigeration as in previous tests (Table 9).

The foil box liner and pliofilm bunch wrappers were quite effective in reducing moisture loss from the flowers as shown in the following comparison of loss in weight during a 12-hour period which included the time in "flight."

Flower	Weight loss		
	Box A pct.	Box B pct.	Box C pct.
Carnation	.4	0	1.5
Chrysanthemum	0	0	3.9
Rose	2.2	.5	5.5
Mean	.9	.2	3.6

Tests Nos. 9 and 10 represent short flights to high altitudes of 30,000 ft. (test No. 9) and 50,000 ft. (test No. 10) similar to tests Nos. 3 and 4, but with fall flowers. Carnation, chrysanthemums, rainbow asters, and roses were used in five small 36" boxes with 5 pounds of "bagged" water ice and 1 pound of dry ice tied to the center cleat.

The boxes were treated as follows:

Box A: Moistureproofed by painting inner and outer surfaces with GEON LATEX 31X. It was covered with crushed ice to obtain maximum cooling and protection from moisture loss during the "flight."

Box B: Coated with latex like Box A, but exposed to air.

Box C: Conventional non-coated box, exposed to air.

Boxes D & E: Same as Box C.

Boxes A, B, and C were used in test No. 9 (30,000 ft. alt.) and Box E was used in test No. 10 (50,000 ft. alt.). Box D was held at sea level at 48°F., 75 percent humidity.

With air in the altitude chamber at 35° to 45°F., 50 percent to 70 percent humidity (test No. 9), the flowers cooled from an average initial temperature of 70°F. to an average of 37° in about 4 hours, Fig. 11, which was a considerably faster rate of cooling than was obtained in previous tests with warmer ambient air.

There was some freezing of the stems and foliage near the dry ice in test No. 9. The slight withering of the petals of chrysanthemums and roses following exposure to 30,000 ft. and 50,000 ft. altitudes, Table 10, was probably due to drying from the low air pressure prevailing at high altitude rather than to freezing since the temperature records indicate that the blossoms were continuously above the freezing point.

The latex coating given boxes A and B was effective in reducing moisture loss from flowers at high altitude as shown by the following comparison:

Flower	Weight loss of flowers in 7-1/2 hours ^{1/}				
	Box A Test #9	Box B Test #9	Box C Test #9	Box E Test #10	Box D Sea level "control"
	pct.	pct.	pct.	pct.	pct.
Aster	2.4	2.1	3.3	5.1	4.6
Carnation	.4	1.4	1.1	1.7	2.6
Chrysanthemum	0	1.4	2.7	5.2	2.9
Rose	1.4	1.8	3.3	2.6	3.6
Mean	1.1	1.7	2.6	3.7	3.9

^{1/} Boxes held in the cold, sea level room with Box D except for the time they were exposed to high altitude conditions.

An increase in the drying effect of air resulting from lowering the air pressure (increasing altitude) is shown with non-moistureproof boxes C and E. However, humidified cold air at 30,000 ft. altitude caused less drying than slightly warmer and drier at sea level.

Commercial Considerations

From the results of these tests there appears to be no injury to flowers at altitudes up to 20,000 ft. and only slight injury to tender varieties such as carnations, roses, and sweet peas at 30,000 ft. altitude. The injury was less severe under cold moist conditions than when the cargo compartment was warm and dry indicating that it was due to the drying effect of air which increases with altitude.

Moisture loss from the flowers was reduced and flower life benefited by using moistureproof boxes or moistureproof box liners.

The ice packed with the flowers helped to cool the boxes but was not enough to supply the full need for refrigeration in flight. Under flight conditions flowers are affected adversely by heat and low humidity the same as they are at sea level.

Dry ice as used in these tests had no effect on lengthening flower life owing to the poor gas retaining quality of the shipping boxes. Only about 4 percent carbon dioxide was present in the boxes after 6 hours and it was completely depleted after 12 hours.

Acknowledgments

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The United Wholesale Florists of California, Inc., packed most of the flowers and the Union Ice Company supplied the ice for the walk-in cold box. Other test material was furnished by the Flintkote Company and Permanente Products Company.

Lockheed personnel assisting with the tests included: R. P. Della-Vedova, C. W. Louthan, D. A. Webster, E. A. Reynolds, R. L. John, engineers, and Robert Imandt, photographer, of the mechanical research department.

Table 1 Flowers Subjected to Altitude Tests

<u>Commodity</u> <u>Spring Flowers</u>	<u>District</u>	<u>Test</u>
Anemone	San Fernando	1
Calla	Santa Ana	1
Candytuft	San Fernando	2
Carnation		
Hothouse	do.	1, 2, 3, 4, 5, 6, 7
Field	do.	1, 2, 3, 4
Cornflower	do.	1
Daisy	do.	1, 2, 5
Delphinium	do.	1, 2, 3, 4
Gardenia		
Semidress	San Francisco	2
Loose pack	Los Angeles	3, 4
Godetia	San Fernando	1, 2
Iris (Dutch)	Redondo	1, 2, 3, 4
Rainbow Aster	San Fernando	7
Ranunculus	San Fernando	1
Rose, Hothouse	Montebello	1, 2, 3, 4, 5, 6, 7
Snapdragon	Redondo	3, 4, 5, 7
Stock	do.	1, 2, 3, 4, 5, 6, 7
Sweet pea	Whittier	1, 2, 3, 4, 5, 6, 7
Sweet William	San Fernando	3, 4
<u>Fall Flowers</u>		
Carnation, field	Santa Barbara	8
	San Fernando	9, 10
Chrysanthemum	San Fernando	8, 9, 10
Rainbow Aster	San Fernando	9, 10
Rose, Hothouse	San Leandro	8, 9, 10
Sweet Pea	San Fernando	8

Table 2 Test Conditions of Simulated Flights with Flowers

Test No.	Altitude Ft.	Climb & Descent Rate Ft/Min.	2 Hr. "flights" No.	Ambient Air Temp. °F.	Humidity Pct.
1	20,000	2,000	4	65	30 to 50
2	20,000	2,000	4	40 to 45	75 to 85
3	30,000	3,000	2	40 to 45	75 to 85
4	50,000	5,000	1	40 to 45	75 to 85
5	10,000	500	4	50 to 60	60 to 80
6	15,000	500	4	50 to 60	50 to 70
7	15,000	500	4	50 to 60	50 to 70
8	20,000	2,000	4	50 to 60	40 to 55
9	30,000	2,000	2	35 to 45	50 to 70
10	50,000	5,000	1	40 to 45	50 to 70

Table 3 Condition of flowers subjected to altitude test No. 1, April 20, 1949.

Altitude 20,000 ft. Rate of climb/descent 2,000 ft/min. Duration 4, 2-hr. periods. Air temperature in altitude chamber 58 to 70°F., humidity 27 to 68%. Control lot held at sea level 62°F., 78% r. h.

Flower	No. Stems	Color	Condition April 22 during refreshing in cold room	Condition April 25 after removal to warm room.
Anemone	25	mixed	Same as control. Flowers open; petals wilted and dropping.	Same as control. Wilted, petals dropping.
Calla	24	white	Same as control. Slight wilting, no discoloration.	Altitude lot not as fresh as control.
Carnation				
Hothouse	25	white)	Same as control. Fresh, no difference between hothouse and field lots.	White lot same as control. Pink lot drying at edge of petals.
	25	pink)		
Field	25	pink)		
	25	red)		
Cornflower	25	blue	Like control, flowers open, fresh.	Same as control, fresh.
Daisy	25	yellow	Like control, flowers open, fresh.	Same as control, fresh.
Delphinium	12	lt blue)	Same as control. Flowers fairly fresh, stems curved, light blue flowers dropping.	Same as control. Blossoms dropping.
	12	dk blue)		
Godetia	25	red	Like control, flowers open, fresh.	Same as control, fresh.
Iris	12	white)	Same as control. Fresh, flowers open.	Like control, fresh, open.
	12	yellow)		
	12	blue)		
Ranunculus	25	yellow	Same as control. Fresh, flowers open.	Slightly wilted, more petal drop than control.
Rose				
"Talisman"	25	copper	Same as control. Fresh, open bud.	Like control. Open, dull bronze color.
Stock	12	white)	Same as control. Petals firm but matted, tops curved.	Same as control. Fresh, petals firm.
	12	orchid)		
	12	purple)		
Sweet Pea				
Tissue wrap	25	white)	Same as control. Slight shatter (loose petals and flowers). Excessive shatter of flesh colored lot.	Same as control. Severe shatter all lots.
	25	flesh)		
	50	pink)		
	25	salmon)		
	25	yellow)		
Sealed bag	50	white)	Same as tissue wrap lot.	Same as tissue wrap lot.
	50	pink)		
	50	lavender)		

Table 4 Condition of flowers subjected to altitude test No. 2, April 25, 1949.

Altitude 20,000 ft. Rate of climb/descent 2,000 ft/min. Duration 4, 2-hr. periods. Air temperature in altitude chamber 40 to 46°F., humidity 72 to 92%. Control lot held at sea level 45°F., 60% r. h.

Flower	No. Stems	Color	Condition April 27 during refreshing in cold room	Condition April 29 after removal to warm room.
Candytuft	24	mixed	Same as control, fresh.	Same as control, fresh.
Carnation				
Hothouse	12	white)	Same as control, fresh.	Same as control, fresh.
	12	pink)		
Daisy	25	white	Same as control, fresh.	Same as control, fresh.
Delphinium	25	dk blue	Same as control, blossoms dropping.	Same as control, severe shatter.
Gardenia				
Semi-dressed	12	white	Same as control, fresh, no yellowing.	Same as control, fresh, no yellowing.
Godetia	25	red	Same as control, fresh	Same as control, fresh.
Iris	12	yellow	Same as control, fresh, opening.	Same as control, fresh, open.
Rose				
"Red Delight"	12	red	Same as control. Fresh, open bud, normal color.	Dull with bluish cast. Alt. lot, edge of petals more curled and bleached.
Stock	12	white)	Same as control. Fresh, stems upright, petals matted but not soft.	Same as control. Fresh, petals firm.
	12	lavender)		
Sweet pea				
Tissue wrap,	25	white)	Same as control. Fresh, no shatter.	Severe shatter, slightly less in control lot except with lavender color.
	25	pink)		
	50	lavender)		
Sealed bag,	25	white)	Same as tissue wrap.	Same as tissue wrap.
	25	lt pink)		
	25	dk pink)		
	25	lavender)		

Table 5 Condition of flowers subjected to altitude tests Nos. 3 & 4, Apr. 27, 1949.

Altitude Test No. 3, 30,000 ft. Rate of climb/descent 3,000 ft/min. Duration 2, 2-hr. periods. Altitude Test No. 4, 50,000 ft. Rate of climb/descent 5,000 ft/min. Duration 1, 2-hr. period. Air temp. in altitude chamber 40 to 49°F., humidity 70 to 90%. Control lot held at sea level 45°F., 65% r. h.

Flower	No. Stems	Color	Condition April 29 during refreshing in cold room.	
			Test No. 3 (Altitude 30,000 ft.)	Test No. 4 (Altitude 50,000 ft.)
Carnation Hothouse	12	red	Same as control, fresh.	Same as control, fresh.
Field	12	white	Same as control, fresh.	Same as control, fresh.
Delphinium	12 12	lt blue) dk blue)	Same as control, fresh, no shatter.	Same as control, fresh, no shatter.
Gardenia Loose pack	12	white	Same as control. Fresh, no yellowing.	Same as control. Fresh, no yellowing.
Iris	12	yellow	Same as control, fresh, opening.	Same as control, fresh, opening.
Rose "Better time"	12	red	Same as control. Fresh, open bud, normal color.	More open than control. Edge of petals slightly dry and curled.
Snapdragon	12	pink	Same as control. Stems curved, petals loose on lower flowers.	Same as control. Stems curved, petals loose on lower flowers.
Stock	12 12	white) lavender)	Same as control. Fresh, up- right, petals firm but matted.	Same as control. Fresh, upright, petals firm but matted.
Sweet Pea Tissue wrap	25 25 25 25	white) salmon) dk pink) lavender)	Same as control. Fresh, very little shatter.	Same as control. Fresh, very little shatter.
Sealed bag	50 50 50	white) pink) lavender)	Same as tissue wrap lot.	Same as tissue wrap lot.
Sweet William	12	mixed	Same as control, fresh.	Same as control, fresh.

Table 6 Condition of flower subjected to test No. 5, - May 11, 1949

Altitude 10,000 ft. Rate of climb/descent 500 ft/min. Duration 4, 2-hr periods. Air temperature in altitude chamber 45° to 60°F., humidity 35 to 95%. Control lot held at sea level 50°F., 65% r.h.

Flower	No. Stems	Color	Box ^{1/}	Condition May 13 after refreshing in cold room and removal to warm room.
Carnation Field	25	mixed	1 & 2 3	Fresher than control. Same as control. Edge of petals dry and dull especially with red flowers.
Daisy	12	white	all	Same as control, fresh.
Rose "Red delight"	12	red	all	Same as control, open buds, some bluish cast.
Snapdragon	12 12	pink) white)	all	Same as control, few lower flowers wilted and drooping.
Stock	12	white	1 & 2 3	Fresher than control. Same as control. Lower flowers wilted and soft.
Sweet Pea	25 25 25 25	white) yellow) pink) lavender)	1 & 2 3	Fresher than control. Same as control, no shatter, Slight crinkling of petals.

^{1/} Box 1. Waxed box cooled with "Superice."

Box 2. Conventional box cooled with water ice. Wet paper laid over stems.

Box 3. Conventional box cooled with water ice in moisture-proof bag.

Control. Same as box No. 3

Table 7 Condition of flowers subjected to test No. 6, May 16, 1949

Altitude 15,000 ft. Rate of climb/descent 500 ft/min. Duration 4, 2-hr. periods. Air temperature in altitude chamber 45° to 65°F., humidity 47 to 84%. Control lot held at sea level at 45°F., 60% r.h.

Flower	No. Stems	Color	Box ^{1/}	Condition May 20 after refreshing in cold room and removal to warm room.
Carnation Hothouse	25	pink	1 & 2 3 & 4	Same as control. Slight drying and browning at edge of petals.
Rose "Better Time"	25	red	1 & 2 3 & 4	Same as control. Aged, bluish cast, drying at edge of petals.
Stock	25 25	white) lavender)	all	Same as control, some limpness to lower flowers.
Sweet pea	50	white) pink) lavender)	1 & 2 3 & 4	Same as control. No shatter. No shatter, slight crinkling of petals.

- ^{1/} Box 1. Cooled with "Superice."
 Box 2. Cooled with water ice. Wet paper laid over stems.
 Box 3. Cooled with water ice and dry ice. Wet paper laid over stems.
 Box 4. Cooled with water ice in moisture-proof bag.
 Control. Same as box No. 4

Table 8 Condition of flowers subjected to test No. 7, May 18, 1949

Altitude 15,000 ft. Rate of climb/descent 500 ft/min. Duration 4, 2-hr. periods. Air temperature in altitude chamber 44° to 65°F., humidity 48 to 78%. Control lot held at sea level at 45°F., 72% r.h.

Flower	No. Stems	Color	Box ^{1/}	Condition May 20 after refreshing in cold room and removal to warm room
Carnation Hothouse	25	pink	1 & 2 3 & 4	Same as control. Slight drying at edge of petals.
Rose "Better time"	12	red	1,2,3, 4	Edge of petals aged and "blue" Same as control, fairly fresh.
"Peters Briar- Cliff"	12	pink	all	Affected same as "Better time."
"Gloria"	12	yellow	1,2,3, 4	Fresh, orange color developing at tip of petals. Like control, fresh, no orange color.
Rainbow Aster	12	mixed	1 & 2 3 & 4	Same as control, fresh. Slight wilting of petals.
Snapdragon	12	pink	all	Like control, lower flowers dropping.
Stock	12	white	all	Like control, few lower flowers soft.
Sweet pea	25 25	white) pink)	1 & 2 3 & 4	Same as control, no shatter. Slight crinkling of petals.

^{1/} Box 1. Cooled with "Superice."

Box 2. Cooled with water ice.

Box 3. Cooled with water ice and dry ice.

Box 4. Cooled with water ice in moisture-proof bag and dry ice.

Control. Cooled with water ice in moisture-proof bag.

Table 9 Condition of flowers subjected to altitude test No. 8, Nov. 16, 1949.

Altitude 20,000 ft. Rate of climb/descent 2,000 ft/min. Duration 4, 2-hr. periods. Air temperature in altitude chamber 53 to 62°F., humidity 35 to 46%. Control lot held at sea level at 50°F., 60% r.h.

Flower	No. Stems	Color	Condition 11/18 during refreshing in cold-room. ^{1/}	Condition 11/21 after 4 days in cold room.
Carnation	12	red	Same as control Fresh, no injury.	Same as control. All slightly wilted and with some bluish discoloration.
Chrysanthemum Large	12	bronze	Same as control. Fresh, no injury.	Flower and foilage fresh. Control (sea level) lot slightly wilted.
Rose "Better Time"	12	red	Same as control. Fresh, buds opening.	Same as control. All buds 1/2 open but too "blue" to be salable.
Sweet Pea	25 25 25	pink) lav.) white)	Same as control. Fresh, very slight shatter.	Altitude lots except those in moisture-proof bags slightly more withered than control. Objectionable shatter in all lots.

^{1/} Flowers from foil-lined Boxes A and B slightly fresher than those in conventional Box C.

Table 10 Condition of flowers subjected to altitude tests Nos. 9 & 10, Nov. 18, 1949.

Altitudes and rate of climb:

Test No. 9. 30,000 ft. (2, 2-hr. periods) 2,000 ft/min.

Test No. 10. 50,000 ft. (1, 2-hr. period) 3,333 ft/min. av.

Air temp. in altitude chamber (both tests) 37 to 43° F., 48 to 76% r. h.

Control lot held at sea level 48°F., 75% r. h.

Flower	No. Stems	Color	Condition ^{11/21} during refreshing in cold room. Test No. <u>9</u> ^{1/2}	Test No. 10
Carnation	20	red	No injury. Color good, stems fresh.	No injury. Color good, stems fresh.
Chrysanthemum Large	9	bronze	Few pale, wilted petals in altitude lot.	Altitude lot slightly more wilted than control.
Rainbow Aster	18	mixed	No injury. Excellent condition.	No injury. Excellent condition.
Rose "Better Time"	20	red	Same as control, slight curling and "bluing" of outer petals both lots.	Same as control, both lots slightly wilted.

1/ No difference in condition of flowers in latex-coated Boxes A and B and conventional Box C.

2/ Slight freezing of stems and leaves near the dry ice.

FIG. 1. RED ROSES SHOWING CURLING OF PETALS DUE TO EXCESSIVE DRYING
AT LOW AIR PRESSURE REPRESENTING 50,000 FT. ALTITUDE.



FIG. 2. CARNATIONS SHOWING SLIGHT CURLING OF PETALS DUE TO EXCESSIVE DRYING AT LOW AIR PRESSURE REPRESENTING 50,000 FT. ALTITUDE.

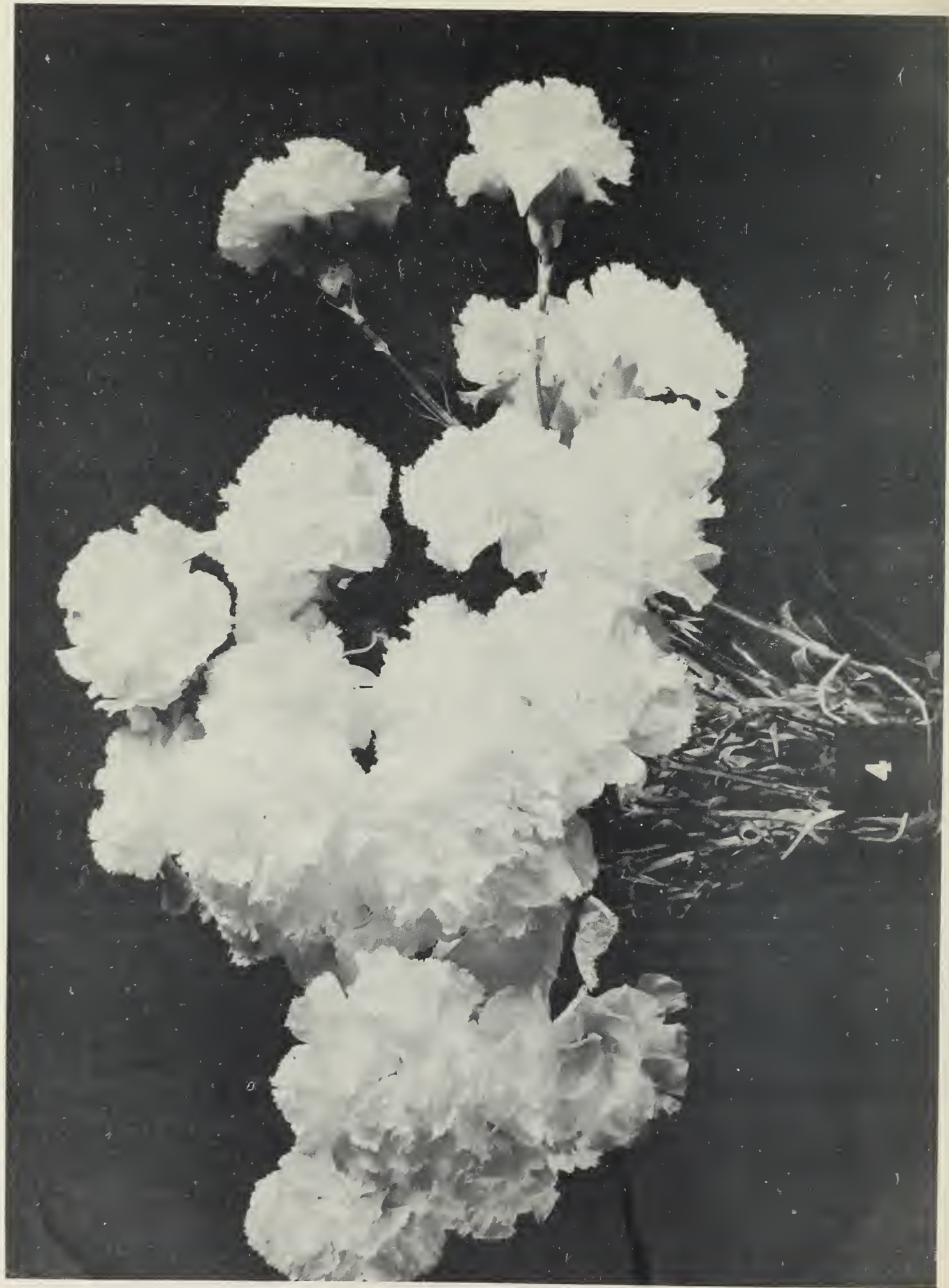


FIG. 3. SWEET PEAS SHOWING SLIGHT CURLING OF PETALS DUE TO EXCESSIVE DRYING AT
LOW AIR PRESSURE REPRESENTING 50,000 FT. ALTITUDE.



FIG. 4. MIXED FLOWERS PACKED IN A SMALL SIZE 36" CORRUGATED FIBERBOARD BOX, 15" WIDE X 9" DEEP.
NOTE NEWSPAPER BOX LINER ALSO ICE PACKAGE TIED TO CENTER CLEAT.



FIG. 5. LOADING THE DECOMPRESSION CHAMBER WITH FLOWERS FROM THE WALK-IN ICE BOX. THE REMOVABLE WINDOW, THE TEMPERATURE, HUMIDITY, AND ALTITUDE INDICATORS ARE SHOWN ON THE TABLE.



FIG. 6. INTERIOR OF DECOMPRESSION CHAMBER SHOWING PACKED BOXES AND FLOWERS EXPOSED FOR OBSERVATION DURING "FLIGHT!"



FIG. 7. DISPLAY OF FLOWERS FROM TESTS NOS. 1 AND 2. AFTER MOST OF THEM HAD BEEN EXPOSED TO LOW AIR PRESSURE REPRESENTING 20,000 FT. ALTITUDE.



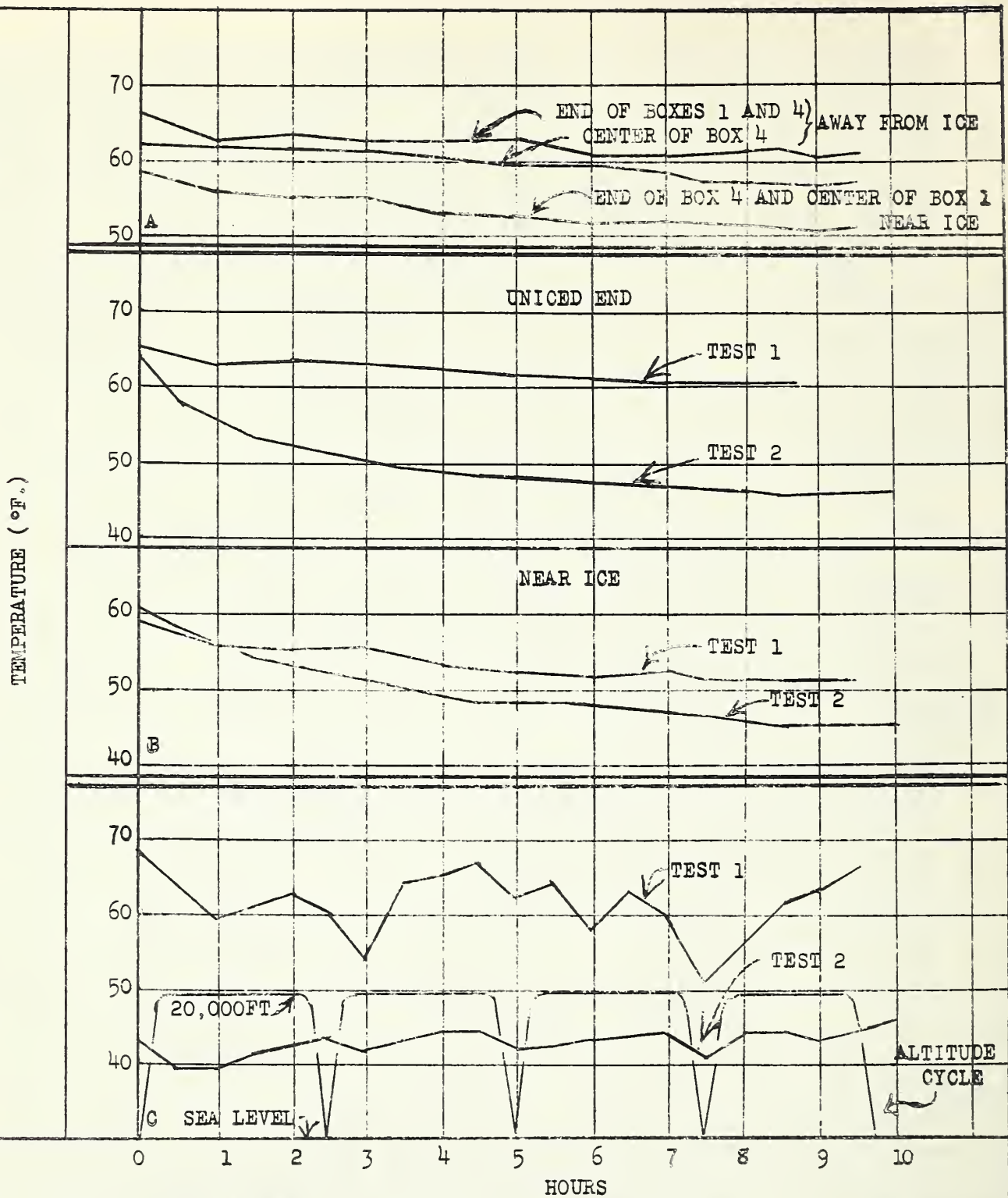


Fig. 8. TEMPERATURES IN BOXES -- (36 INCH) OF FLOWERS PACKED WITH 5 POUNDS OF ICE. PLACED IN MOISTUREPROOF BAGS.
 BOX 1 - ICE PLACED AT CENTER OF BOX.
 BOX 4 ICE PLACED AT END OF BOX.
 A. FLOWERS NEAR ICE AND SOME DISTANCE AWAY FROM IT. TEST 1
 B. FLOWERS IN WARM AND COOL "FLIGHTS." TEST 1 AND 2 RESPECTIVELY.
 C. AIR TEMPERATURES IN TEST 1 AND 2 AND "ALTITUDE" RECORD

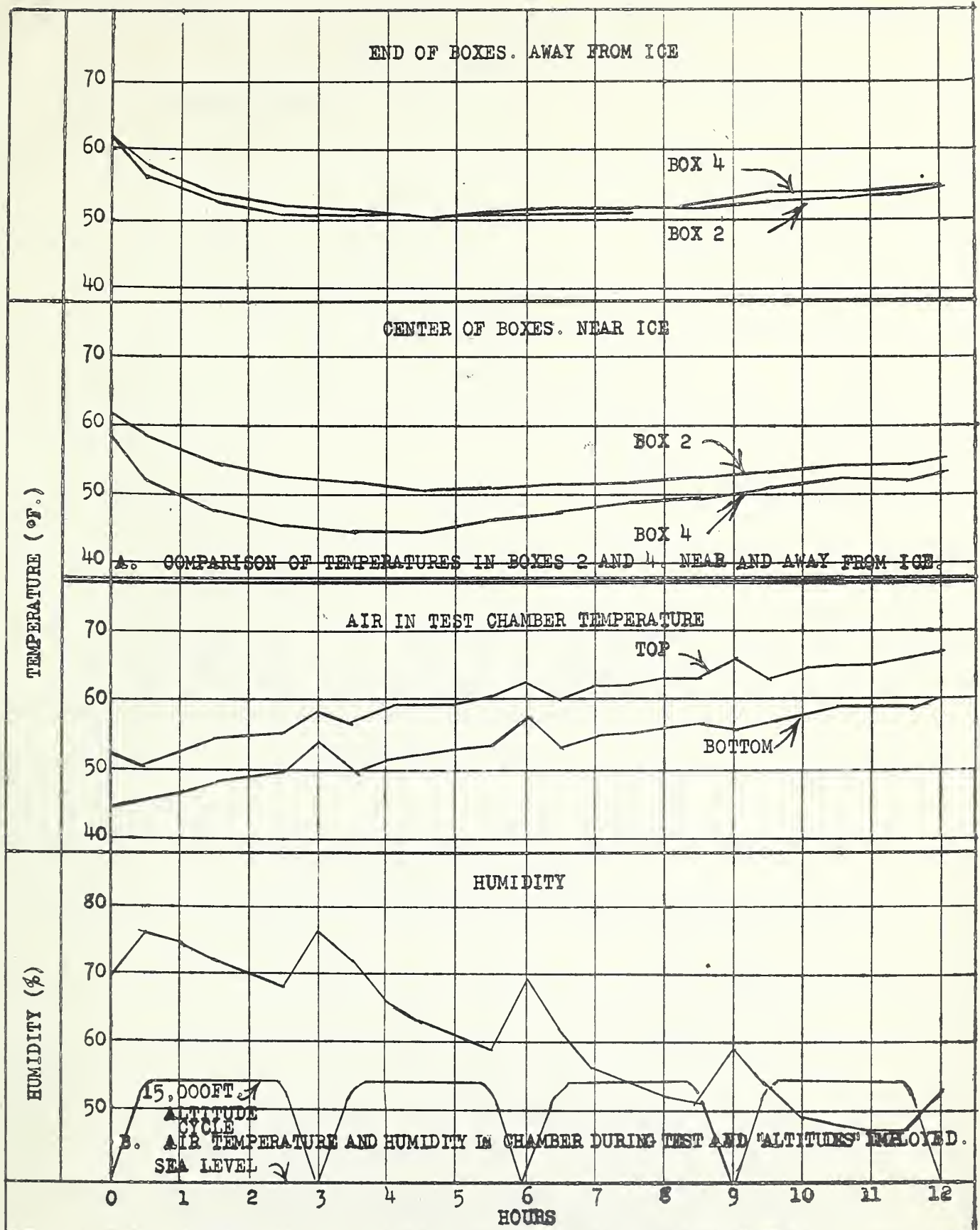


Fig. 9 FLOWER TEMPERATURE IN TWO "SMALL" 36 INCH BOXES, TEST NO. 6 BOX 2 WITH 5 POUNDS OF ICE AND WET PAPER (A MOIST PACK). BOX 4 WITH 5 POUNDS OF ICE IN MOISTUREPROOF BAG AND ONE POUND OF DRY ICE OUTSIDE THE BAG (A DRY PACK).

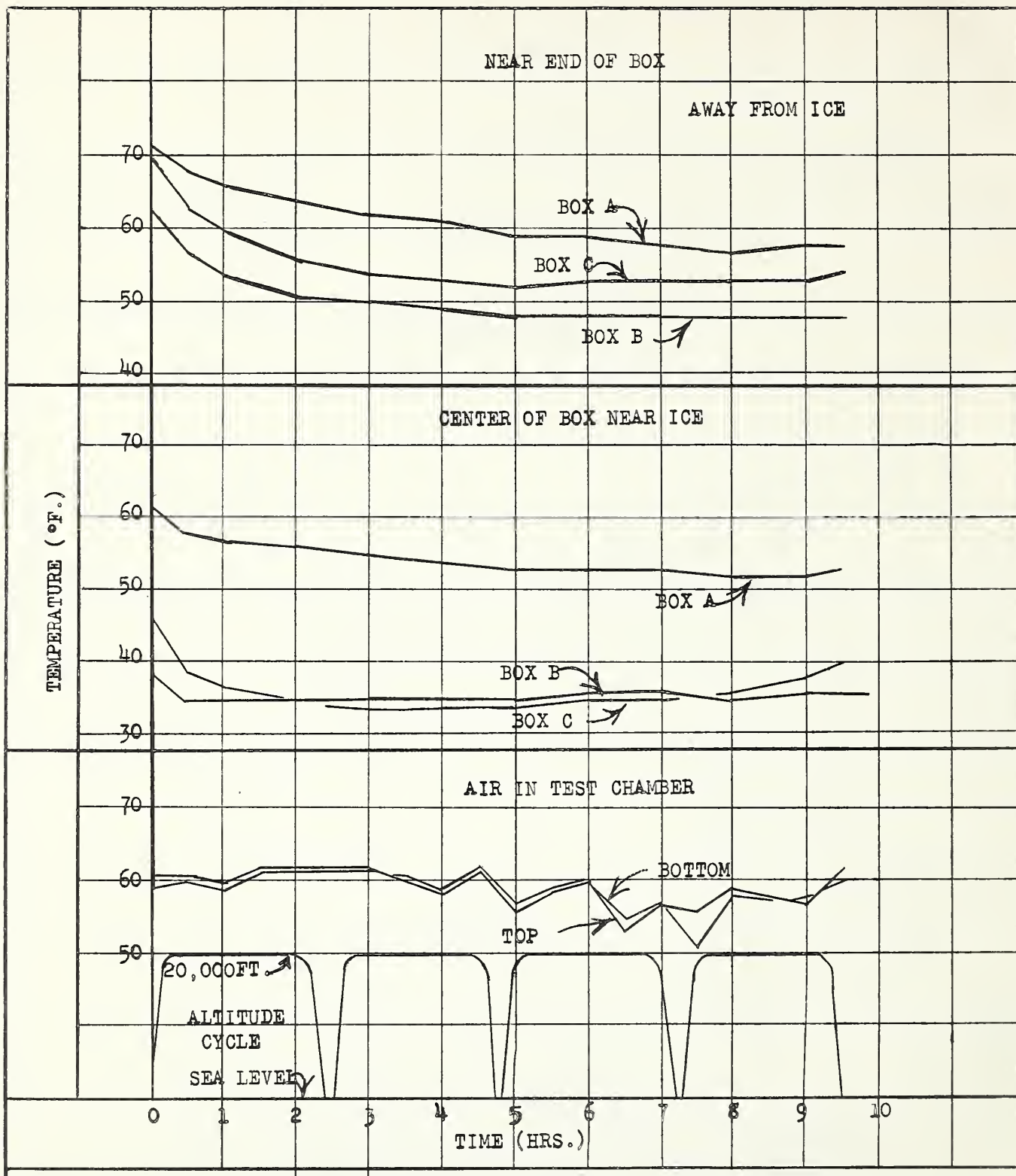


FIG. 10 FLOWER TEMPERATURE IN 3 "SMALL" 36 INCH BOXES, TEST NO. 8

BOX A: FOIL LINER, PLIOFILM WRAPPERS, 5 POUNDS ICE IN MOISTURE-PROOF BAG AND 1 POUND DRY ICE OUTSIDE THE BAG.

BOX B: SAME AS BOX A, BUT WITH 25 POUNDS OF ICE IN MOISTURE-PROOF BAGS.

BOX C: NEWSPAPER LINER, TISSUE WRAPPERS, ICED LIKE BOX A.

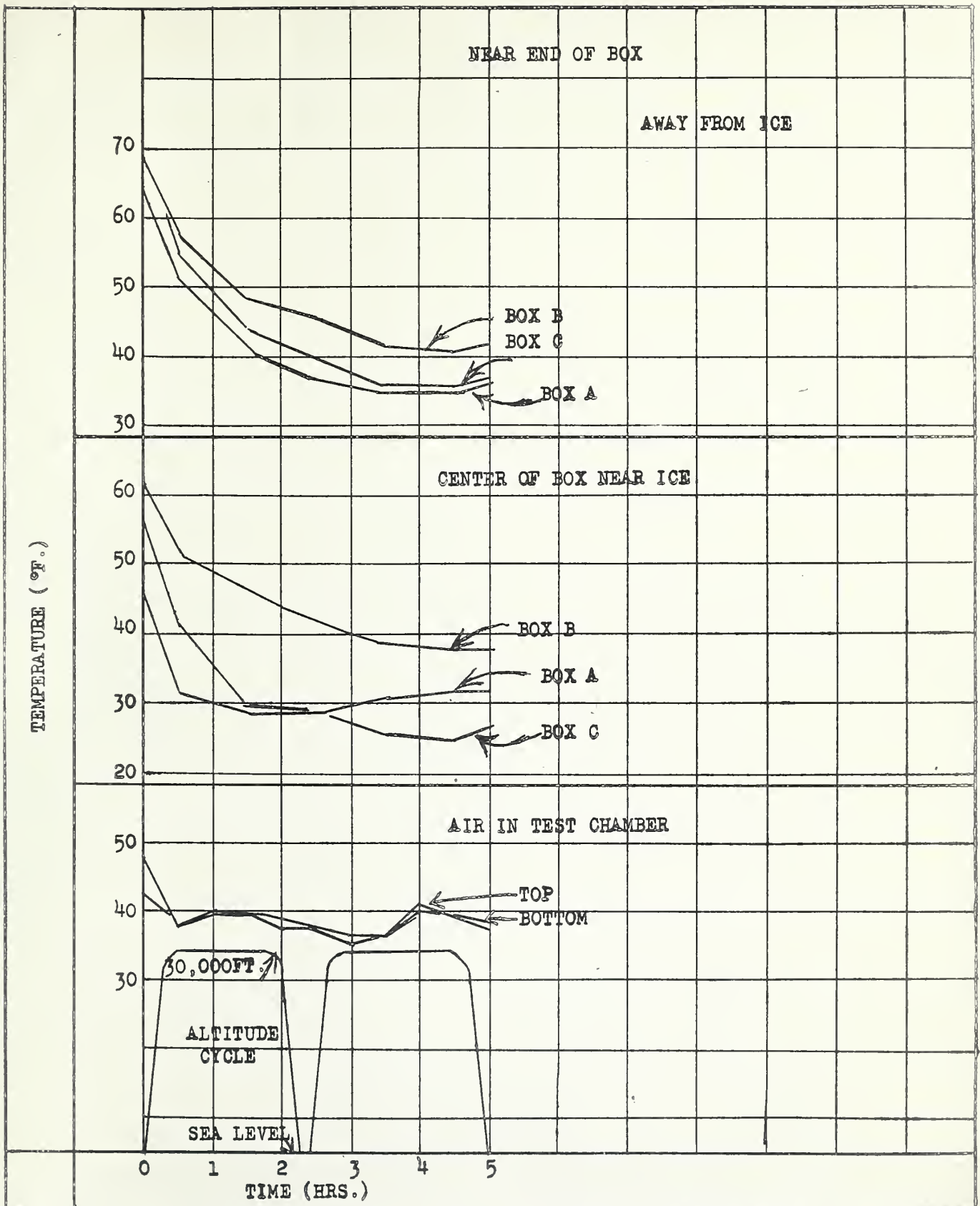


Fig. 11 FLOWER TEMPERATURE IN 3 "SMALL" 36" BOXES, TEST NO. 9

Box A: LATEX-COATED, COVERED WITH CRUSHED ICE.
 BOX B: SAME AS BOX A, BUT EXPOSED TO AIR.
 BOX C: NON-COATED, EXPOSED TO AIR.
 (ALL BOXES CONTAINING 5 POUNDS OF ICE IN MOISTURE-PROOF BAG AND 1 POUND OF DRY ICE OUTSIDE.)

